Automatic meshing of Discrete Fracture Networks

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Key words: DFN, mesh generation, flow simulation

Introduction

DFN models may contain a large number of fractures, whose sizes span over several order of magnitudes. In addition, fracture intersections also have a wide range of sizes. Their influence is reinforced by the presence, in natural fractured media, of specific configurations like T-terminations that should be properly handled. The rock matrix is considered impervious here. The challenge is to build a mesh of the fractures with necessary quality for subsequent flow simulations. We require that the generated mesh:

- includes the fracture intersections and the highly critical T-terminations, whatever their size and position in the fracture plane,
- contains a relevant number of elements to accurately model the flow properties but which remains reasonable for the flow simulation to be feasible.

Presented work

We will present BLSURF_FRAC software, which first builds a geometric model including fracture intersections. In a second phase, it generates a mesh of the geometric model by calling an associated planar mesher [1]. The general scheme is the following :

1. Compute the intersections of the disks and save topological information;
2. Split curves and find common extremities (for intersections and disks boundaries);
3. Build valid curve discretizations;
4. Generate a mesh of each planar disk, using a user-selected planar mesher, and create the final tridimensional mesh.

The first three steps are handled by BLSURF_FRAC software. The main difficulty is to build valid curve discretizations (step 3). To do so, BLSURF_FRAC implements automatic corrections. As planar meshers (step 4), we propose to consider the two followings, BAMG and BL2D.

As benchmark test cases, we extend those proposed in [2, 3] to DFNs generated with the UFM framework [4, 5]. They are large scale DFNs where the fracture size distribution matches the observations and where fractures are organized so that large fractures inhibit the smaller ones, creating T-termination configurations. As illustration, we present the results on such a DFN, called DFNL50. Figure 1 shows this DFN, made of 3477 fractures, together with the meshes obtained with BAMG and BL2D respectively, using a constant mesh step.

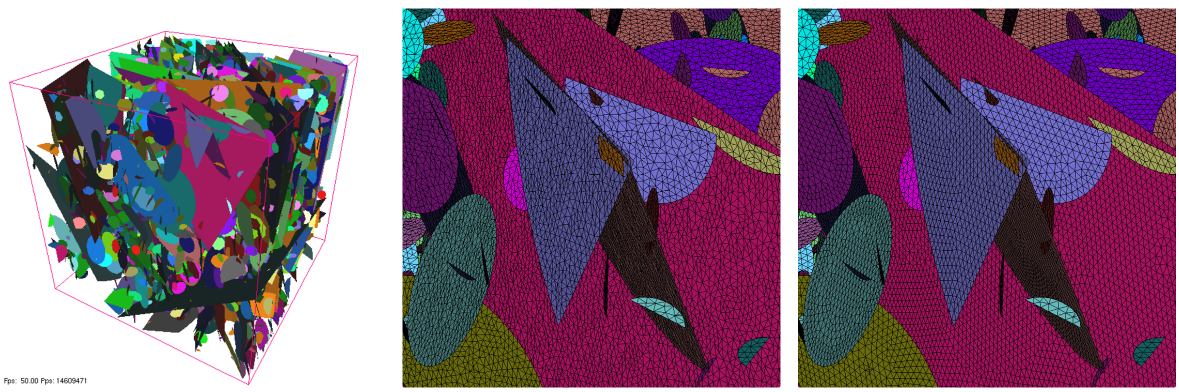

Figure 1: (Left) DFNL50 Test case: 3477 fractures, 4334 intersections. Zoom on the mesh generated with: (middle) BAMG: #triangles: 1,513,802; (right) BL2D: #triangles: 1,450,993.

BL2D also has the abibility to adaptively refine the mesh, for more accurate and less expensive flow computations. As an example, figure 2 illustrates, for the same network, DFNL50, a mesh refinement around the intersections, with a significant reduction of the number of triangles, by comparison with the number of triangles obtained with a constant mesh step generation (as shown on Figure 1).

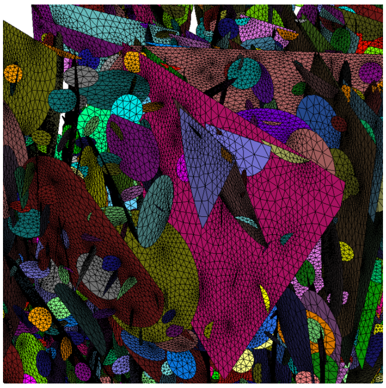

Figure 2: DFNL50 Test case - Adaptive mesh refinement with BLSURF - # triangles: 591,117.

Finally, we will also present the results of steady-state single phase flow solutions on different benchmark test cases. Figure 3 shows the flow solution, for a permeameter test case, on the network DFNL50 meshed with BLSURF_FRAC combined with BL2D.

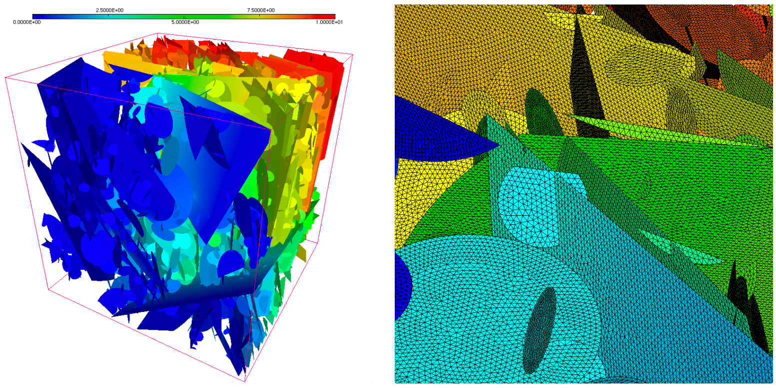

Figure 3: (Left) Mean hydraulic head computed on the network DFNL50. (Right) Zoom on the conforming mesh generated by BLSURF, #triangles: 5,924,391.

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